Dual Time-Of-Flight-Energy for the Advanced Mass and Ionic Charge Composition Experiment (AMICCE)

Completed Technology Project (2018 - 2021)

Project Introduction

Executive Summary We recently demonstrated the potential application of an innovative electrostatic analyzer (ESA) with variable radius of curvature that increases sensitivity of a suprathermal ion instrument(Allegrini et al., Rev. Sci. Instrum. 2009; Allegrini et al., J. Geophys. Res. 2016). The Advanced Mass and Ionic Charge Composition Experiment (AMICCE) combines this ESA with a proven design for measuring time-of- flight (TOF) and residual energy (E) to uniquely determine elemental, isotopic, and ionic charge composition over a wide energy range. AMICCE will measure ionic charge states of heavy ions (He-Fe; 10-500 keV/q) with resolution of $\Delta q/q \leq 0.2$. The ESA uses only four voltage steps to cover the entire E/q range, decreasing duty cycle and yielding nearly 10x sensitivity gain over current suprathermal ion instruments. AMICCE has mass resolution $\Delta m/m \leq 0.15$ to separate rare isotopes like 3He from the more abundant 4He. We propose to enhance AMICCE's capabilities with a high energy channel, using its original TOF section to measure isotopic and elemental composition of ions from ~0.1–5 MeV/nucleon. The new TOF-E design combines two channels: 1) “Lo” for suprathermal ions (described above) and 2) “Hi” for energetic particles entering the TOF-E section through a collimator and C-foil. The TOF design uses electrostatic mirroring of secondary electrons emitted from thin C-foils or Si detectors. The Lo and Hi channels share the same start and stop MCP detectors. Ion residual energy is measured with avalanche photodiodes (Lo) and SSDs (Hi), enabling simultaneous measurement of 1) ionic charge state, isotopic, and elemental composition of the largely unexplored suprathermal ions and 2) isotopic and elemental composition of heliospheric energetic ions. Objectives and Methodology The goal is to demonstrate feasibility of a dual TOF-E section for AMICCE. We have a fully characterized prototype of the ESA and a partial prototype of the TOF section. We therefore define three objectives: 1. Electro-optics design and modifications to prototype: Incorporate the Hi channel into the current TOF design, iterate the design, and fabricate the modified parts. We’ll use Simion for electro-optics simulation. 2. TOF-E test and characterization: Test and characterize the TOF-E section with ion beams (H through Fe, ~5 to 450 keV/q), measuring TOF and residual energy for both Lo and Hi channels. 3. AMICCE test and characterization: Perform end-to-end test of the full AMICCE prototype (ESA mounted to the TOF-E section), characterizing its response to known ion beams. Relevance to NASA and the Science Community An AMICCE-type flight instrument will advance understanding of the poorly explored suprathermal particle population and therefore of processes that accelerate particles during SEP events and that govern their transport through the solar corona and heliosphere. AMICCE will satisfy the requirements of suprathermal and energetic particle instruments to address NASA's strategic objective to “Understand the Sun and its interactions with Earth and the solar system, including space weather.” Understanding the suprathermal population directly addresses aims of the 2014 Roadmap, including: “Understand the plasma processes that accelerate and transport particles” (F2), “Understanding the role of the Sun and its variability in driving change in the Earth's

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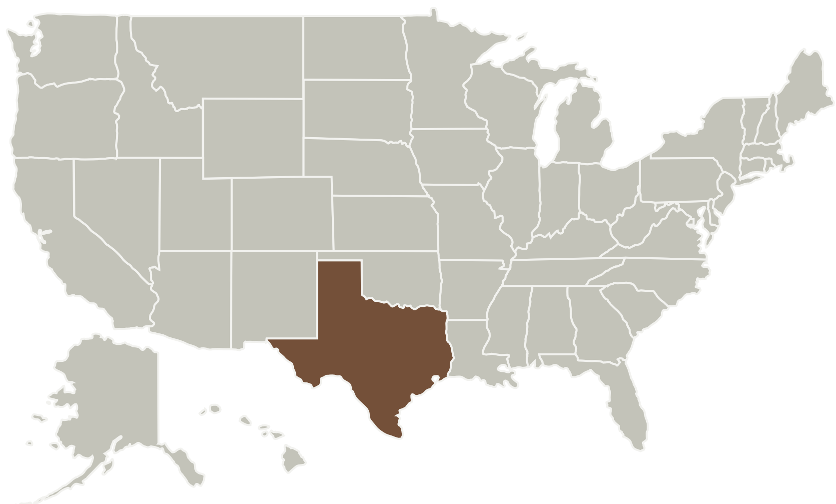
atmosphere, the space environment, and planetary objects” (H2), “Determine the interaction of the Sun with the solar system and the interstellar medium” (Goal 3), and “Discover and characterize fundamental processes that occur both within the heliosphere and throughout the universe” (Goal 4). This proposal is within the scope of the H-TIDeS program, improving performance of an existing instrument concept by combining the Lo and Hi channels into a single detector section, saving mass and power, and providing higher sensitivity than present instruments in a similar energy range.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Southwest Research Institute - San Antonio(SWRI)	Lead Organization	Academia	San Antonio, Texas

Primary U.S. Work Locations
Texas

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Southwest Research Institute - San Antonio (SWRI)

Responsible Program:

Heliophysics Technology and Instrument Development for Science

Project Management

Program Director:

Roshanak Hakimzadeh

Program Manager:

Roshanak Hakimzadeh

Principal Investigator:

Frederic Allegrini

Co-Investigators:

Roman G Gomez
Ronald B Kalmbach
Maher A Dayeh

Technology Maturity (TRL)

Start: **4**
Current: **4**
Estimated End: **6**

1 2 3 4 5 6 7 8 9

Applied Research | Development | Demo & Test

Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.3 In-Situ Instruments and Sensors
    └ TX08.3.1 Field and Particle Detectors

Target Destination

The Sun